# Measuring the erosion of river channel widths impacted by watershed urbanization using historic aerial photographs and modern surveys

**#H41D-0768**

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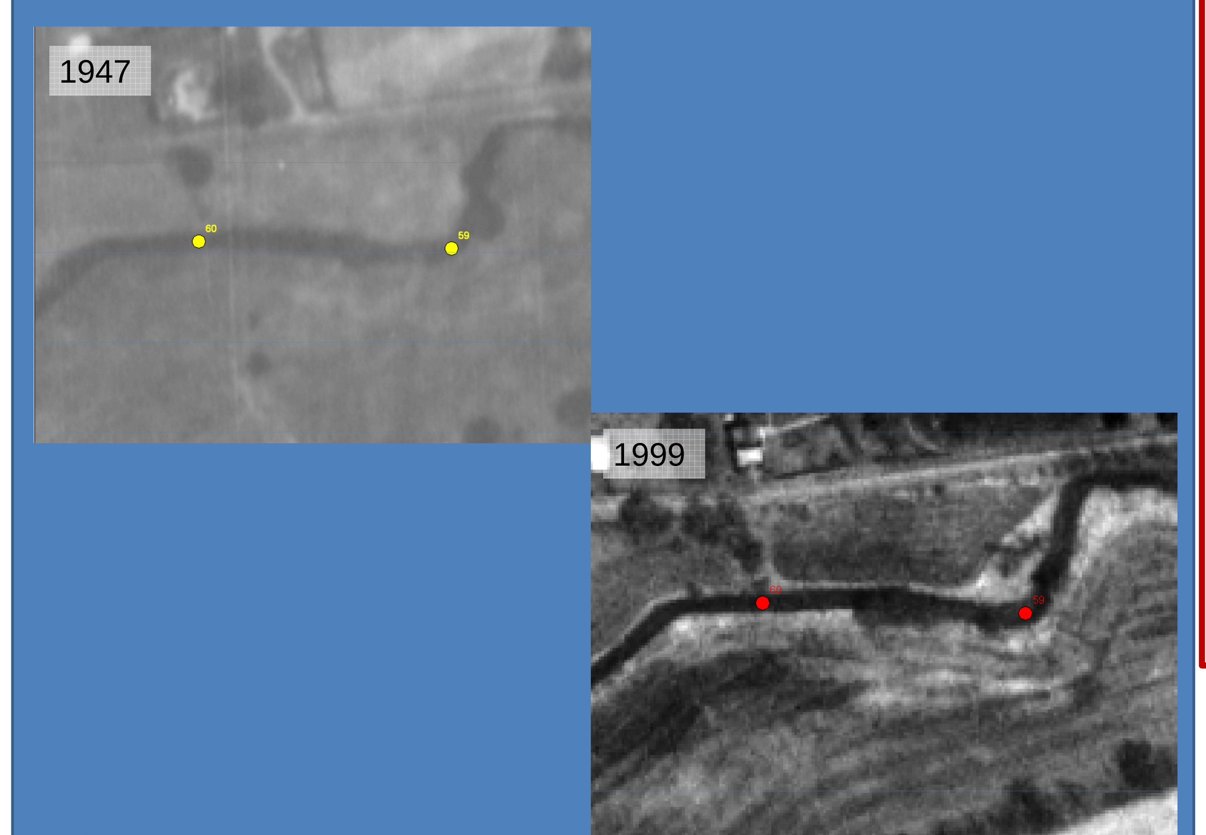
## ABSTRACT

Land use in a watershed exerts a strong influence on trunk channel form and process. Land use changes act over human time scales that are short enough to measure their effects directly using historic aerial photographs. We show that high-resolution topographic surveys comparing channel form for paired watersheds in the Lehigh Valley, PA , are indistinguishable, but have channel widths that have changed dramatically in the past six decades. These five watersheds are similar in size, relief, and climate, and all have predominantly sedimentary lithologies. Four watersheds (Jordan, Little Lehigh, Hokendauqua, and Lizard) exhibited widening in their channels, while the Sacony watershed had a mix of wider and narrower channels. However, the single stretch of Sacony Creek that did widen was that reach downstream of the only sizable urban area in the watershed. The current land use in Sacony Creek watershed resembles that of 1946, while the Little Lehigh Creek watershed has more than tripled its urban area. Qualitatively the land use in the Jordan and Hokendauqua has urbanized, while the change in Lizard Creek watershed is unknown at this time. These data suggest that the increase in urban areas that subsequently increases peak discharges is the mechanism behind the widening that occurred in the Little Lehigh Creek. These wider channels can affect water quality, aquatic habitat, suspended sediment loads, and river aesthetics.

## Methods

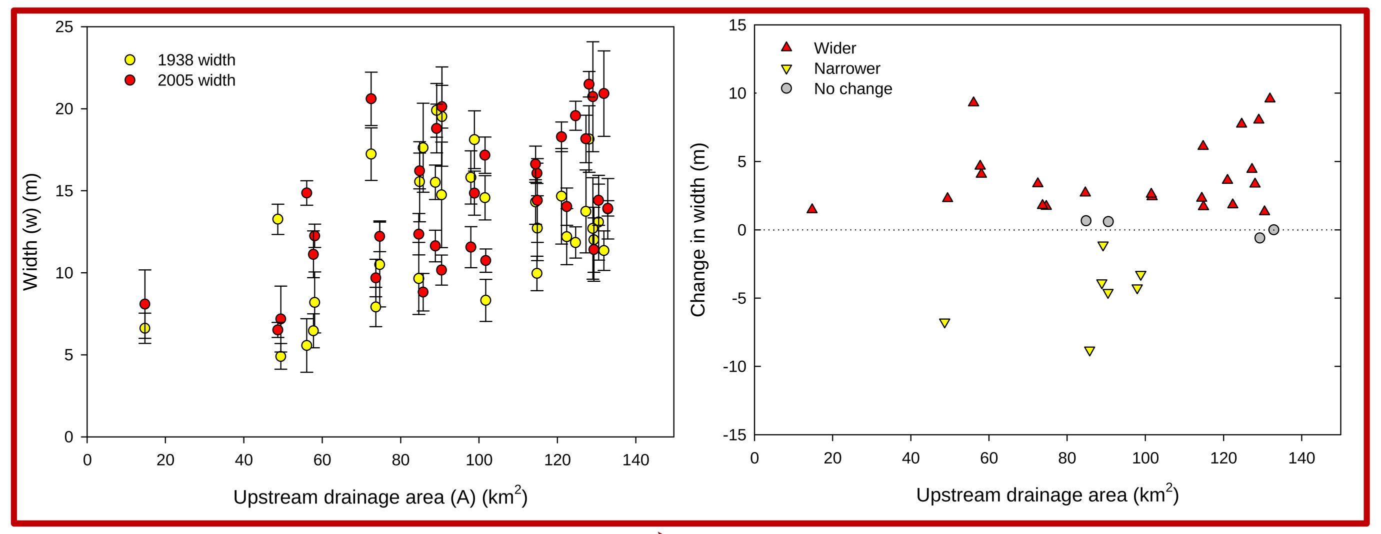
**Historic aerial photographs**

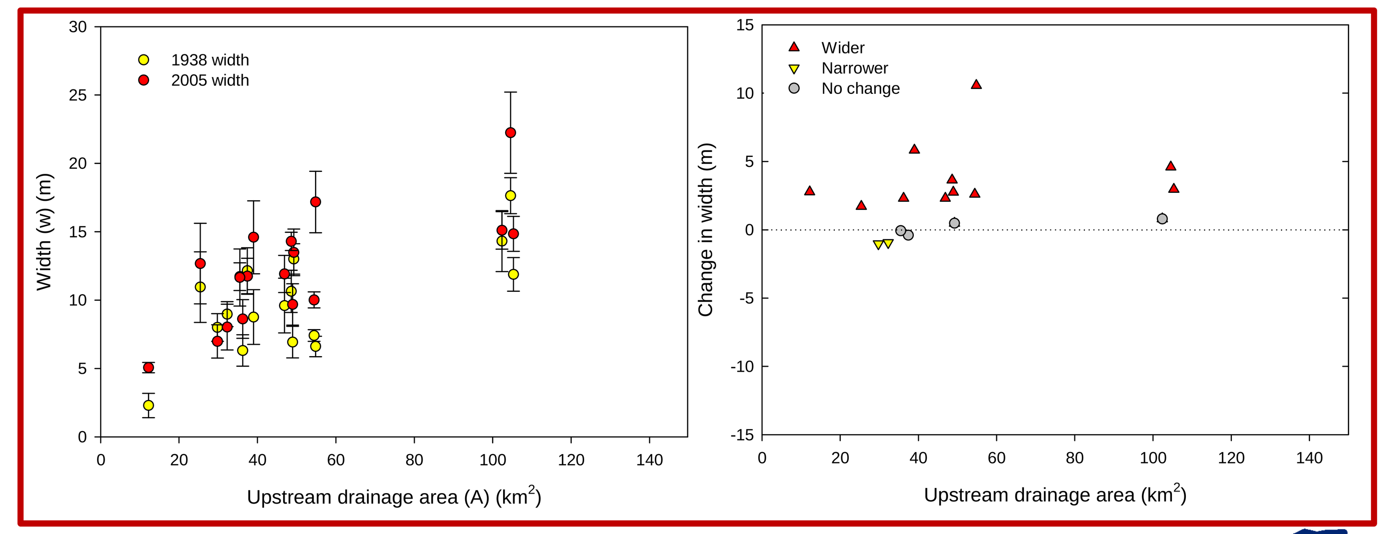
The black and white photographs (1:20,000) were originally taken by the United States Department of Agriculture for their Agricultural and Stabilization Conservation Series. The 1938/1946/1947 photographs were digitized and georeferenced in Earth Science Research Institute's (ESRI) ArcMap 8.3 and 9.2. Modern channel widths were measured from the 1999 and 2005 digital orthophotographs (DOQQs). Points were established for each stream for the old and modern photographs at locations where both stream banks were visible for both sets of years. The width of the trunk channels was measured using the georeferenced aerial photographs and a GIS at 1:900 scale ten times to determine precision. Bankfull widths were determined by the using the change from dark shaded pixels to light shaded pixels (Mount et al., 2003). Ground truth and benchmarks were also established and measured, both of which showed this method to be robust.



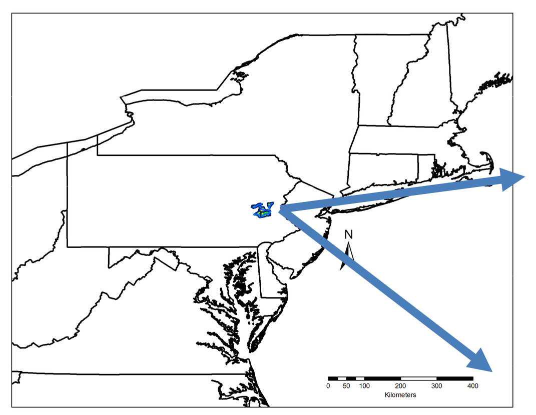

**Modern surveys**

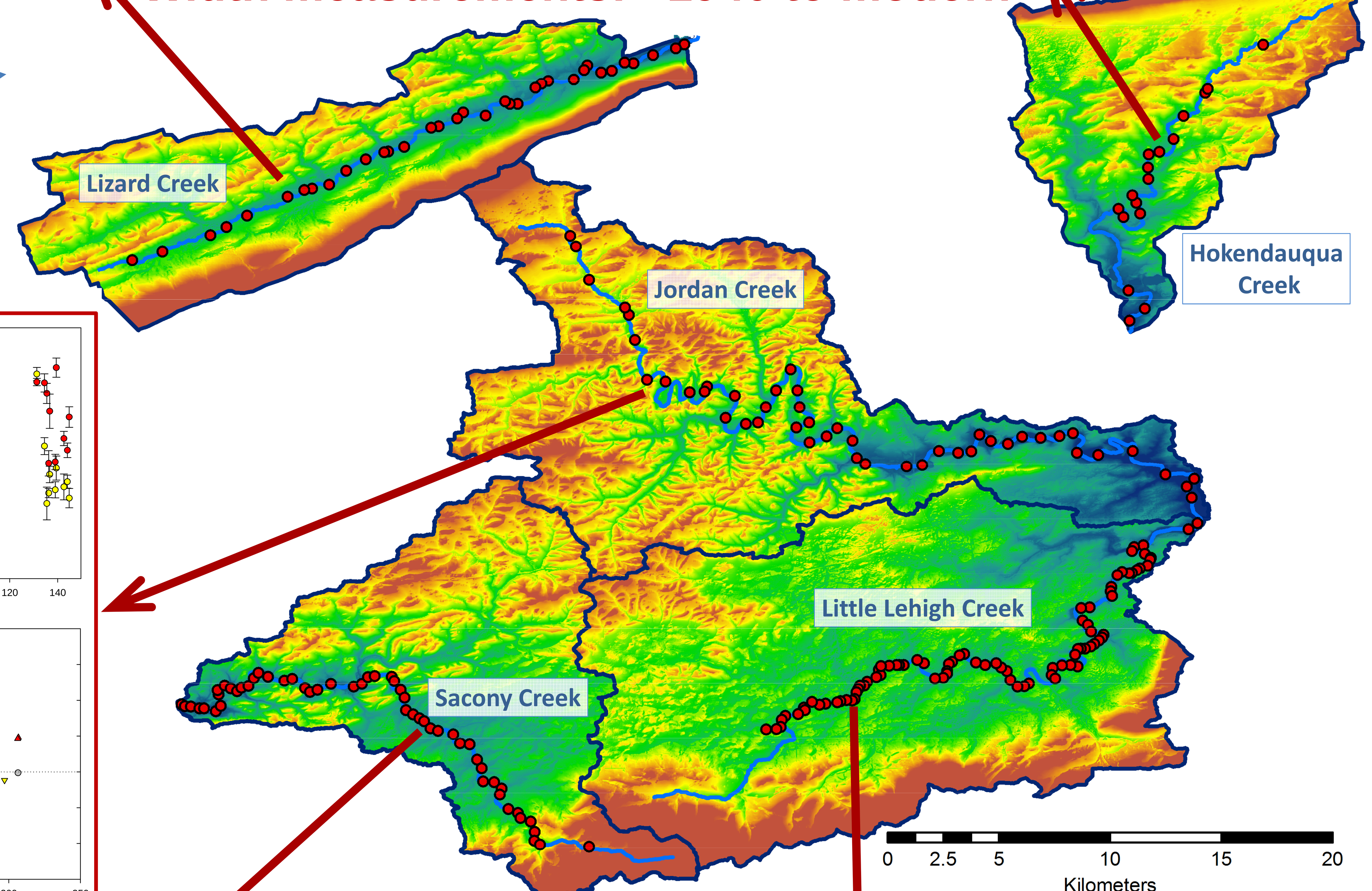
Modern channel morphologies were mapped and compared through high-resolution topographic surveys of channel reaches. These reaches were selected so that an 80 to 100 m reach could be surveyed using a total station (Topcon GTS-211D). Points were surveyed along each bank, along the thalweg, and for multiple cross-sections and were used to generate a digital elevation model (DEM) of the channel in Surfer (v. 6.03). This DEM was then used to measure the bankfull widths and depths along the reach, as well as to calculate the average reach volume and area.

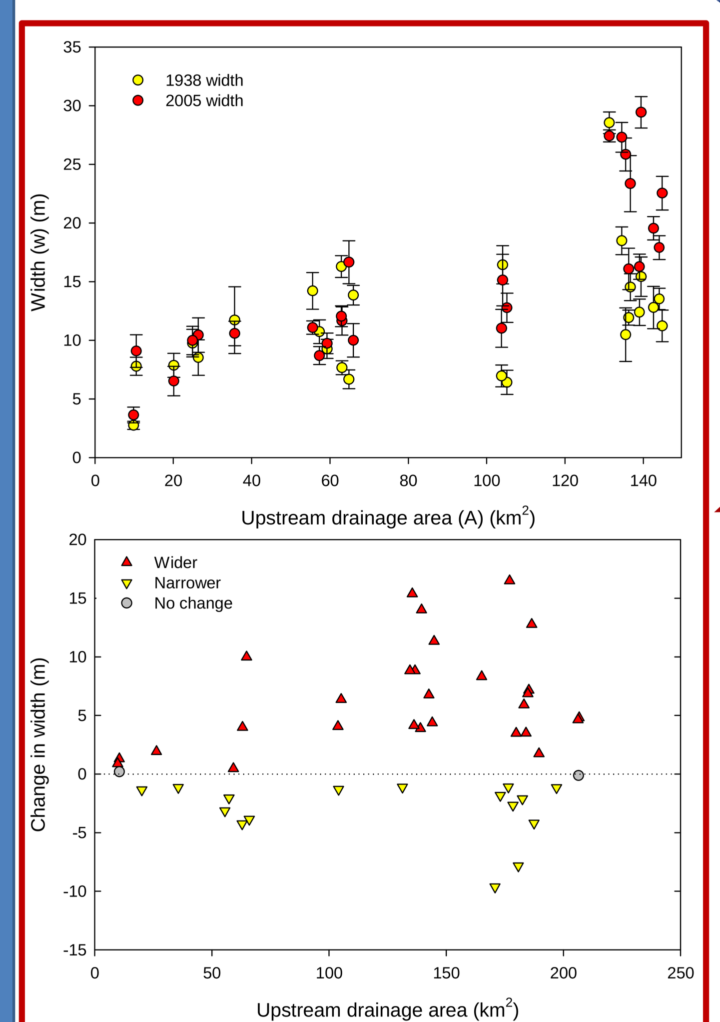


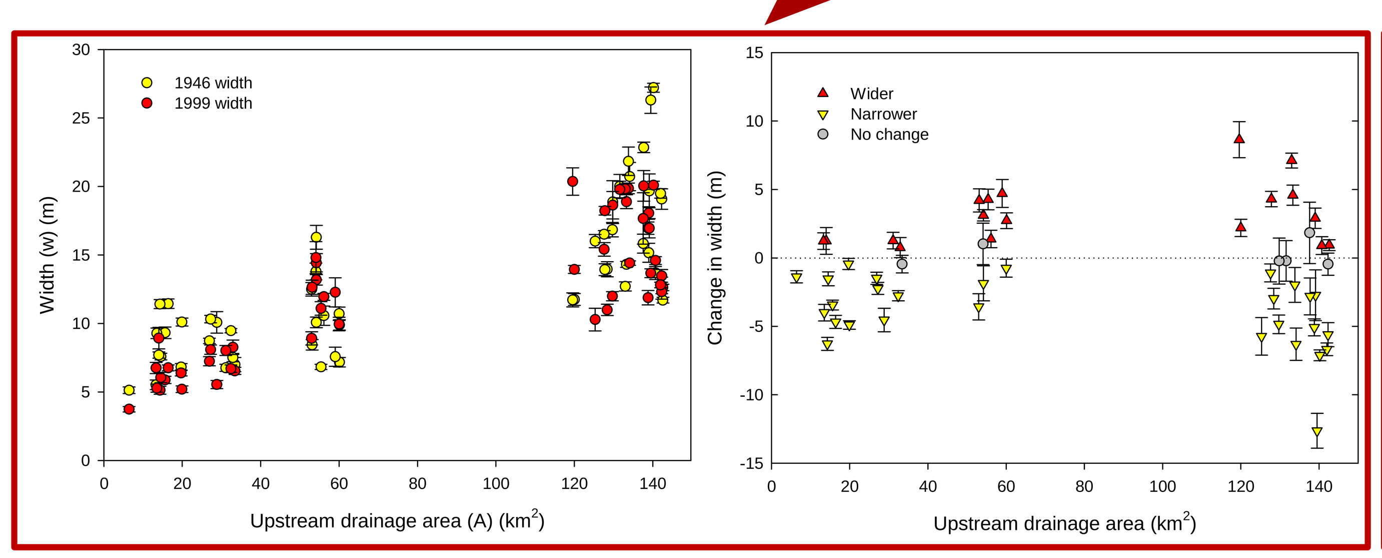



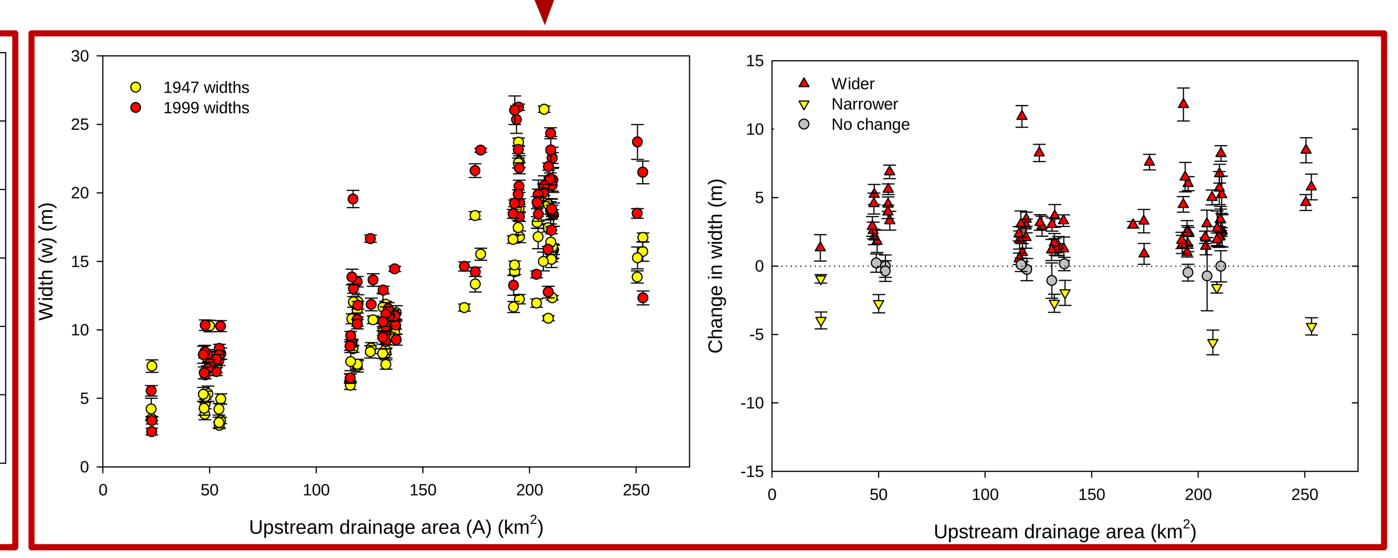

## Width measurements: ~1940 to modern

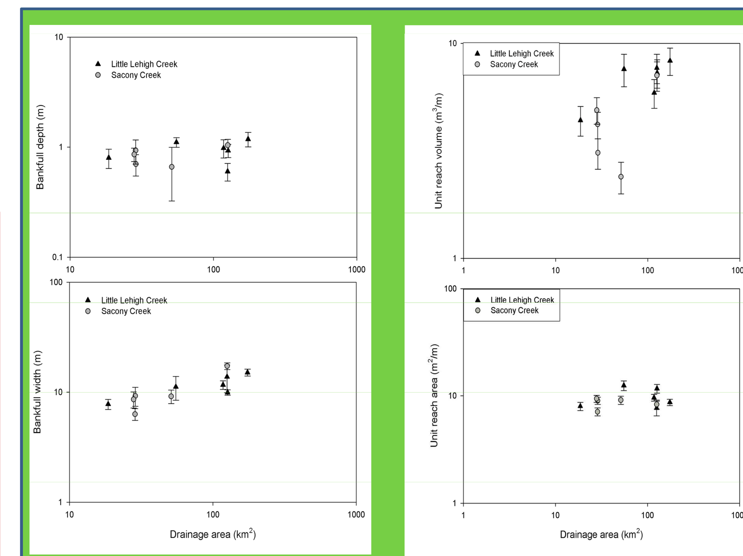




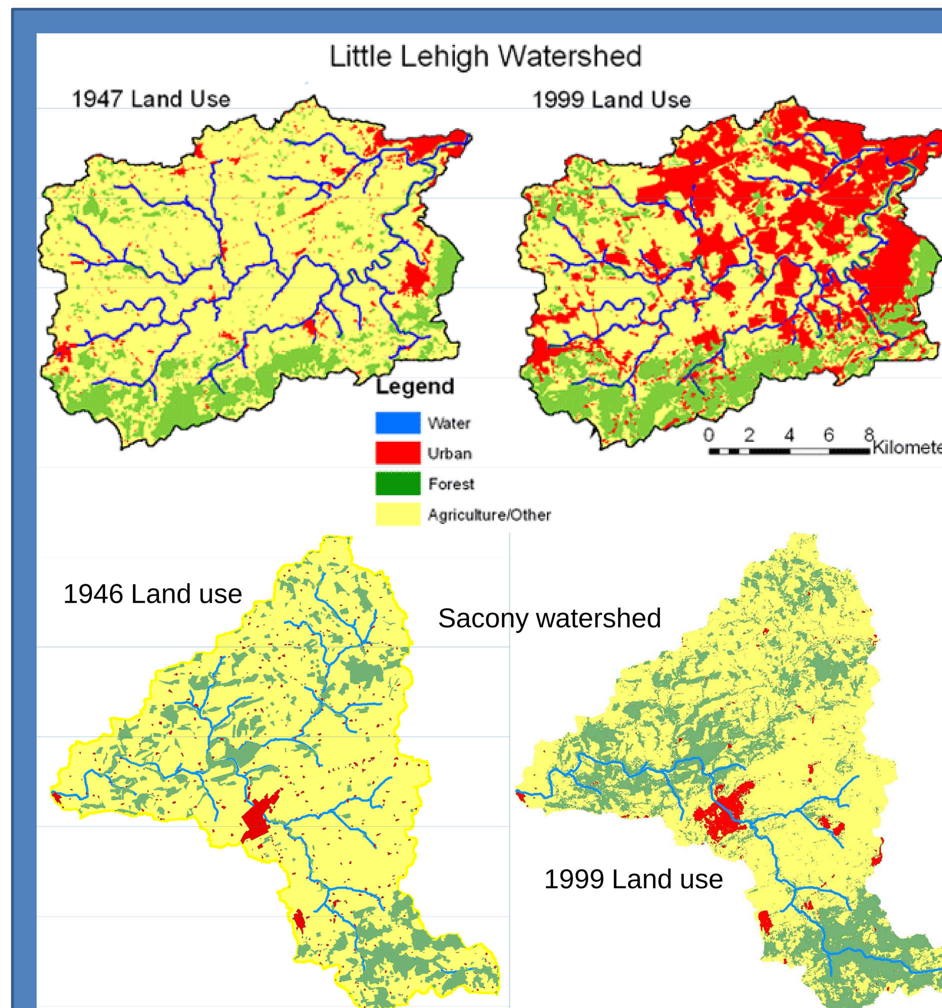



## Modern surveys

Detailed topographic maps were made for five reaches for both the Sacony Creek and Little Lehigh Creek. Bankfull widths and depths (left graph) and average unit reach volume and area (right graph) for the two streams were compared. However, no differences existed between the two despite of their different land use and change in widths over time. This demonstrates that the natural variability in stream channels may disguise real differences in stream morphology.




## Land use history

Land use was classified in the GIS from the 1946/1947 photographs for Sacony Creek and Little Lehigh Creek into three categories: urban, agricultural/open, and forest. These three categories are broader than those typically used for land use/land classification (LULC), but simpler categories were used to reduce the chance of misclassification. The Little Lehigh watershed increased in urban land use from 5% to 30% from 1947 to 1999, while the Sacony watershed remained mostly rural (urban increasing from 2% to 3%) in the same time period. Future work will classify the land use history for the other watersheds.

## Results

The measured widths from the aerial photographs were able to quantify the change in channel width from ~1940's to the present. Four of the five watersheds widened along a majority of their channel measurements, with only the Sacony Creek showing a mix of widening and narrowing channels. Sacony also had the most stable land use pattern of the five watersheds, while the other four watersheds had increasing amounts of urbanized areas.

| Watershed | Drainage Area (km²) | # of wider channels | # of narrower channels | # of channels with no change | Land use change (~1940 to present) |
|---|---|---|---|---|---|
| Little Lehigh | 254 | 67 | 8 | 10 | Urbanized |
| Sacony | 143 | 18 | 28 | 6 | No change |
| Jordan | 209 | 28 | 16 | 2 | Urbanized |
| Lizard | 184 | 22 | 7 | 4 | Unknown |
| Hokendauqua | 146 | 12 | 2 | 4 | Urbanized |

## Conclusions and next steps

Historic aerial photographs were critical for measuring the change in channel widths over time that were not visible through a paired-watershed (Little Lehigh and Sacony) approach. The Little Lehigh, Jordan, Hokendauqua, and Lizard watersheds all widened over most of their channel measurements during the last ~60 years. Using the Sacony watershed and its stable land use history as a control, we suggest that the land use change from rural to urban in the other four watersheds has driven the erosion and channel-widening. The land use history for Jordan, Lizard, and Hokendauqua watersheds needs to be completed for better comparison with Little Lehigh and Sacony watersheds. Also, expanding the number of studied watersheds will strengthen these conlcusions.